Eco. Env. & Cons. 28 (1) : 2022; pp. (315-318)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i01.045

A study on Incorporating Zero Energy Building Features in a Residential Building

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(Received 11 May, 2021; Accepted 30 June, 2021)

ABSTRACT

Any building has significant impact on the energy use and the environment which can potentially affect the development of a country. It is highly important to minimize energy usage to preserve the environment. Energy usage also causes climatic changes, environmental degradation and increases the air pollution. The amount of energy utilization should be considerably reduced in all types of buildings to make environmentally sustainable towns and cities. The buildings that utilize minimum energy and discharges minimum waste in to the environment can be called zero energy buildings. Zero energy buildings offer numerous advantages to the society as a whole. The aim of this study is to focus on the zero energy components that can be incorporated to create Net Zero energy by using various energy resources. The study discusses the various energy optimization features in a residential building of around 2000 sq. ft area. The building is energy sufficient building and it uses renewable energy sources for heating and power generation to operate the electrical and electronic appliances.

Key words : *Zero energy building, Climate changes, Environment pollution, Renewable energy resources, Energy sufficient building.*

Introduction

The zero energy building is also known as Net zero energy buildings (NZEB). The term of Net Zero Energy building is defined as the building with zero net energy consumption. Commercial and residential buildings account for about 33% of the total electricity in India. Currently, there are only a small number of highly efficient buildings that meet the criteria to be called "Net Zero". The recent development in construction technologies, renewable energy approaches, and extensive research, helps in maximizing the count of zero energy buildings. The net-zero site energy building tends to produce the same amount of energy consumed when measured at the site (Kulkarn *et al.,* 2020; Perlova *et al.,* 2015). This energy is usually produced at the site itself using renewable energy sources, and also applies energy efficient technology in utilizing the produced energy. The net zero energy consumption principle is viewed as a means to reduce carbon emissions and reduce dependence on fossil fuels.

Methodology

The literature review and articles were collected through various sources related to zero energy buildings. With the help of these literatures and articles, various features existing in zero energy building were collected. The features such as orientation, ventilation, landscaping, material and construction techniques, lighting in buildings, renewable re-

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sources such solar panels, PV arrays, solar heating, wind turbines, rainwater harvesting and sewage treatment facilities were thoroughly studied. Based on the features of zero energy building, a building plan was prepared of 2000 sq.ft. area as shown in Figure 1. Then features listed for a zero energy building was incorporated in the model building plan. After installation, the comparison on energy consumption in conventional building and zero energy building were analyzed.

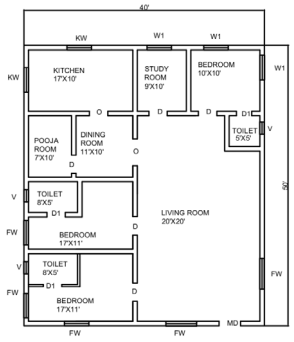

Fig. 1. Building plan

Features of Zero Energy Buildings

Functional designing

A residential building plan consisting of only ground floor including a hall, two bedrooms, two toilets and one kitchen was prepared. The division of the rooms in the plan has been done as per the condition of zero energy building. The plan has been designed by using Auto CAD software and other necessary structural components are designed manually. In view of all the limitations in building by laws and by Vastu Shastra the plan was prepared having floor area of 2000 square feet. Building dimensions, orientation, and openings are mentioned in the plan view. This building is designed for minimizing the consumption of water and electricity for comfort requirements as well as for lighting. This building utilizes the natural resources such as renewable energy devices like solar PV panel unit, solar power refrigerator, low water fittings, rain water harvesting etc.

Orientation

The building is constructed as south oriented, which is favorable for effective ventilation. Orientation minimizes heat ingress. Window to wall ratio of the building is optimum according to the energy conservation. Eastern and western windows are shaded with opaque roller blinds.

landspacing

The building with more area of greeneries is an essential feature of zero energy building which aids in minimizing heat islands. More than 50% of the area outside the planned building is covered with native plants as they are capable of reducing water consumption. Greeneries can also improve the health of the occupants.

Ventilation

The window uses high-efficiency low heat transmittance index double glazed glass of U-Value 0.049 W/m^2K. The hermetically sealed UPVC windows which reduce the incoming heat and use of high reflectance terrace tiles (Cool roofs) are provided (Purbantoro and Siregar, 2019). Light shelves have been provided for diffused sunlight and Stone and Ferro cement jalis are provided which lower the temperature by compressing the air through the holes.

Material and Construction Technique

Building constructed with the use of low embodied energy and a recycled content-based product like autoclaved concrete blocks with fly ash, fly ash-based plaster and mortar. The building can be constructed by providing local stone flooring, bamboo jute composite doors, frames, and flooring (Habash *et al.*, 2014). These products are of low embodied energy. A two hour fire rated doors can be used for main doors. Flooring can be done with carpet tiles. They are made of recycled polypropylene which is an eco- friendly material. Gypsum boards and fiber cement boards are used for Wall section. Gypsum boards have a two hour fire rating. The fiber cement boards are weather resistant. Over a building green roof with local plants are provided it is used as part of insulation as well as cooling system, water is stored on roof in small tanks which is used for plants (Vijay *et al.*, 2020).

lighting in the building

Lighting is the most important component in any modern building. Lighting accounts to 20–30% of total building energy consumption. In the proposed building, lighting is provided with solar PV panels of 3 kW capacity and these panels are mounted on the roofs tilted south direction to get maximum solar energy. Each room in the building has LED lights

which reduces the energy consumption (Thakare *et al.*, 2020; Khandelwal *et al.*, 2020). The bamboo pergolas are provided in the building which makes more efficient, cost effective and environmental friendly shading device. The applications of sensors are also used in the planned building for occupancy sensing, daylight sensing, and communication elements for lighting control system. The control system uses a network of sensors which automatically control artificial lighting levels depending on the amount of natural sunlight within designated areas.

HVAC Energy Efficiency

The HVAC system of a building is designed fully during the final stages of the building design. HVAC system generally contains a source of heating and cooling, a distribution system, and a technique for supplying fresh air. These include boilers, furnaces, and electric resistance heaters which are typically used to add heat to buildings and for cooling air conditioning units, heat pumps, or cooling towers. The building has solar water heating systems to provide hot water requirement of heating. The building has chiller which supplies chilled water for cooling purpose. For refrigeration purpose, a solar refrigerator is installed in the building and radiant cooling systems are used as it is low energy cooling method (Banerjee, 2015; Shinde *et al.*, 2017). The air conditioning system of the uilding during the warm period of operation must be combined with the scheme of ventilation. To minimize the building's heating and cooling energy consumption, two systems were integrated into the HVAC design. First, an air-source heat pump and second waste heat and cooling recovery systems.

Photovoltaic Array

To generate strength, a photovoltaic (PV) array composed of mono-crystalline silicon modules is used. First the area of roof that is available to install solar-PV array. The array is placed at south orientated. However, beyond rooftops, solar modules can also be mounted on building envelopes also to cover home warm water. The energy produced by the solar-PV array allows the building to achieve a total value of 89% energy offset (Devraj *et al.*, 2018). This building is fully utilized by solar powered energy where 3/4th of building energy is balanced by the solar energy. Figure 2 shows a comparison of energy consumption in conventional and zero energy building.

Wind Turbines

The wind flow near the house can be effectively utilized to produce electricity with the help of wind turbines. Now-a-days new small scale wind turbines have been designed which are almost silent and is far more efficient at converting wind in to energy (Maheshwari *et al.*, 2017). It can generate 1000kWh of energy per year at wind speeds as low as 11miles per hour. That would be enough to cover half an average household's energy needs.

Energy Control

Requirements for control systems to achieve efficient performance and regulation of various facilities can be organized in several categories. In this building, the home automation manage unit is positioned. Intelligent devices, which include TVs and stereo units, are used in this residential building. These devices can be attached to the house automation controller and for faraway operation. Sometimes lights are managed to dim the mild without switching it off. Using ingenious devices, room lighting can be managed by proximity sensor mounted at respective regions (Sruthi and Gokuldeepan, 2018). The machine is programmed so that the lighting fixtures are switched off or dimmed up after 30 seconds of the room is unoccupied. The energy-efficient ceiling fans, air- conditioner or the weather controller can also be programmed in each room. Inside the kitchen, the primary energy-eating devices are electric oven, dishwasher, and fridges. Refrigerators with inverter generation are used to reduce power intake. Microwave and dishwashers are related to smart gadgets so they can be set on or off remotely. This leads to energy savings.

Rainwater harvesting and sewage tretament

Rainwater harvesting is the accumulation and depo-

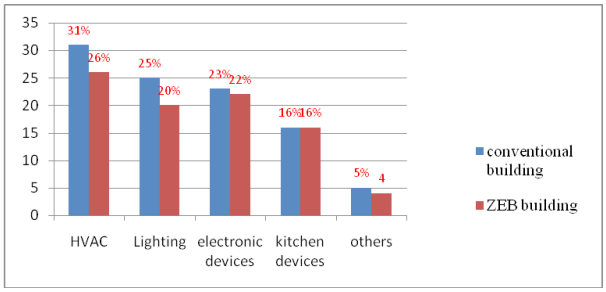

Fig. 2. Energy consumption in conventional and Zero Energy Building

sition of rainwater for reuse on-site, rather than allowing it to run off. Rainwater can be collected from roof, the water collected is redirected to a deep pit, a reservoir with percolation, or collected from dew or fog with nets or other tools. Its uses include water for gardens, livestock, irrigation, domestic use with proper treatment, and indoor heating for houses etc (Viswateja, 2018). The roof pipes are embedded with radiant cooling pipes with chilled water flowing through them giving the place a natural air cooling effect. The building has rain water harvesting system which collects the rain water that runs off from the roof of the building and is collected in a recharge tank. Hence it recharges the water table beneath. The harvested water can also be used as drinking water after sufficient treatment, longer-term storage and for other purposes such as groundwater recharge, which leads to cost saving (Lu *et al.,* 2019). The sewage water from the building is treated and is recycled for landscaping, flushing toilets and make up water for the cooling tower. The treated water can be used for gardening, plantations etc.

Conclusion

High energy consumption is a threat to many changes which adverse for the life on earth as it is causing global warming. To deal with this issue, alternative solutions are required which fulfill the energy demand. The zero energy buildings are the future eco- house. Though understanding of zero energy building is still lesser to many but will get a boost as it is in favor of everyone. The concept of zero energy will reduce global warming and helps to retain the nature. In this project we have completed the design of the Net Zero Energy Residential Building by using special materials instead of normal material used in conventional building. Also this building is designed to optimize the usage of water, chilled water and hot water and STP and solar energy conversion using suitable energy conversion devices. The Comparison of the Conventional Building and net zero energy building was completed by using the parameters such as HVAC, lighting, electronic devices also energy generated by using renewable resources such as solar panels, solar water heating, wind turbines etc. Thus this paper gives the clear cut idea on designing zero energy building and its energy management for the effective consumption of energy from the various energy efficient elements employed in this building.

References

Habash, G., Chapotchkine, D., Fisher, P., Rancourt, A., Habash, R. and Norris, W. 2014. Sustainable Design of a Nearly Zero Energy Building Facilitated by a Smart Microgrid. *Journal of Renewable Energy.* 725850.

Khandelwal, R., Jain, R. K. and Gupta, M.K. 2020. Case Study: India's First Net-Zero Energy Building-Indira Paryavaran Bhavan. *International Journal of Scientific and Technology Research.* 9(11) : 353-57.

Kulkarn A., Shewal, P., More, A., Shinde, D. and Gosavi, H. 2020. Design of zero energy building for sustainable construction: A review. *International Journal of Creative Research Thoughts.* 8(5) : 3736-3742.

Maheshwari, S., Chauhan, P., Tandon, S. and Sagar, S. 2017. A Review Study on Net Zero Energy Building. *International Research Journal of Engineering and Technology.* 4(4) : 1567-1570.

Perlova, E., Platonova, M., Gorshkov, A. and Rakova, X. 2015. Concept Project of Zero Energy Building. *Procedia Engineering.* 100 : 1505-1514.

Purbantoro, F. and Siregar, M. 2019. Design of Net Zero Energy Building (NZEB) for Existing Building in Jakarta. *IOP Conf. Series: Earth and Environmental Science.* 399.

Reshmi Banerjee 2015. Importance of Net Zero Energy Building. *International Journal of Innovative Research in Advanced Engineering.* 5(2) : 141-145.

Sagar, E. Shinde, Anushka, B. Chavan and Gayatri, S. Ghodke, 2017. Implementation of zero energy. *International Journal of Advance Research in Science and Engineering.* 6(3) : 49-54.

Saravan Devraj, Kapilan N., Nagaraja, T. and Albert, M. 2018. Studies on Zero Energy Building. *International Journal of Applied Engineering Research.* 13(1): 136-140.

Sruthi, J. and Gokuldeepan, P. 2018. Design of net zero energy residential building. *International Journal of Advance Research, Ideas and Innovations in Technology.* 4(3) : 1395-1397.

Thakare, N.U., Manwar, U., Tiwari, S., Shrivastava, A. and Motdhare, T. 2020. Design of Zero Energy Residential Building. *International Research Journal of Engineering and Technology.* 7(9): 2422-2444.

Vijay, J., Vanitha, V., Janakiraman, G., Lokeshwaran, S. and Sriram D. 2020. Design of Zero Energy Building and its Energy Management. *International Journal of Advanced Science and Technology.* 29(11s): 534-39.

Viswateja, T.V. 2018. Planning and design of net zero energy residential building (NZERB). *International Journal of Advanced in Management, Technology and Engineering Sciences.* 8(IV) : 576-586.

Yuehong Lu, Xiao-Ping Zhang, Zhijia Huang, Jinli Lu and Changlong Wang, 2019. Definition and Design of Zero Energy Buildings. *Green Energy Advances.* DOI: 10.5772/intechopen.80708.